Neutrino Oscillation Parameters in a Six-Channel Reduced Rank See-Saw

G. J. Stephenson, Jr. (UNM)
T. Goldman (LANL)
B.H.J. McKellar (Melbourne)

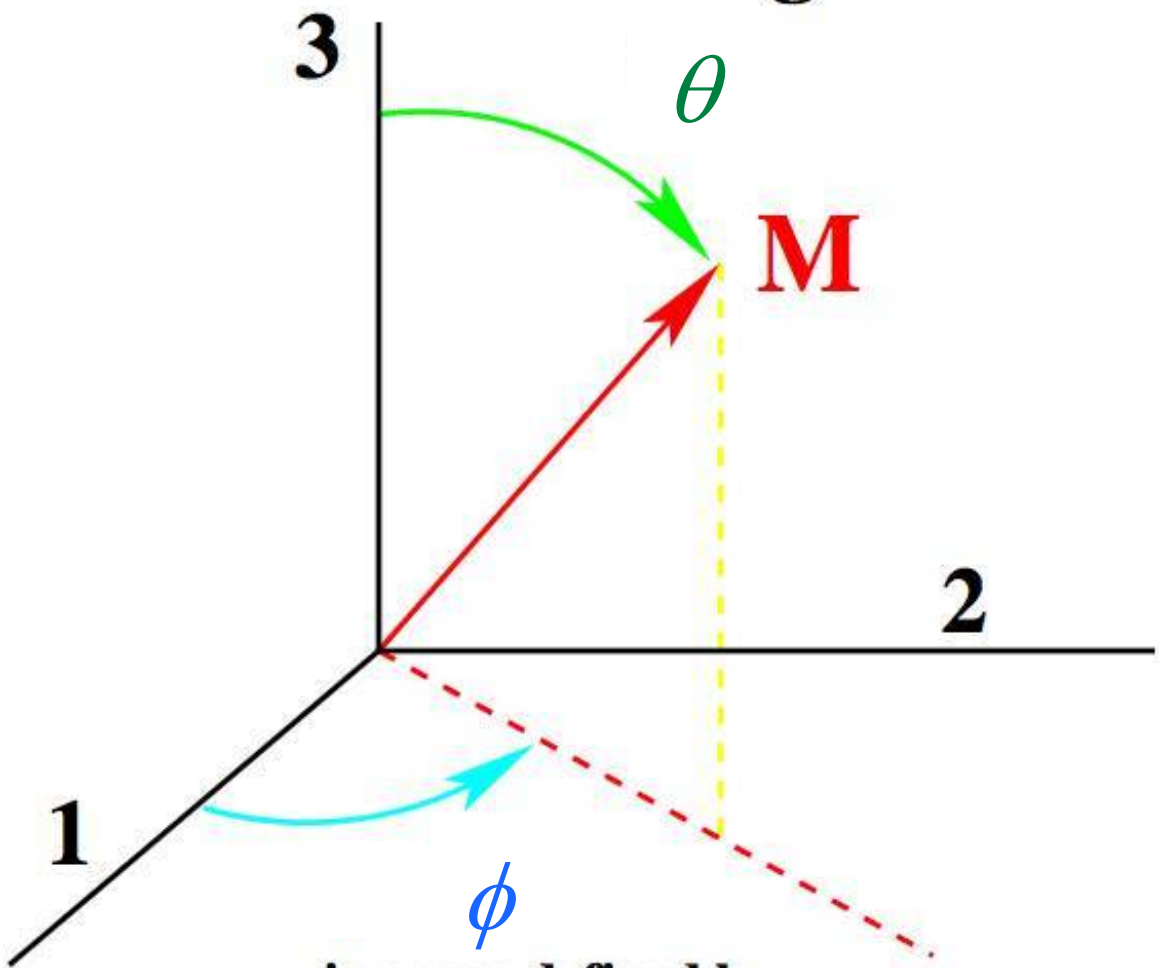
Based on "3+2 neutrinos in a see-saw variation",
G.J. Stephenson, Jr., T. Goldman, B.H.J. McKellar
and M. Garbutt, to appear in *IJMPA*
[hep-ph/0404015]

3 Flavor, Rank 1 Sterile Mass Matrix

Diagonal Dirac mass matrix defines "sterile flavors"

0	0	0	m_1	0	0	ν_{af}
0	0	0	0	m_2	0	ν_{ag}
0	0	0	0	0	m_3	ν_{ah}
m_1	0	0	0	0	0	ν_{sf}
0	m_2	0	0	0	0	ν_{sg}
0	0	m_3	0	0	M	ν_{sh}

Direction of Single Massive Sterile Eigenstate

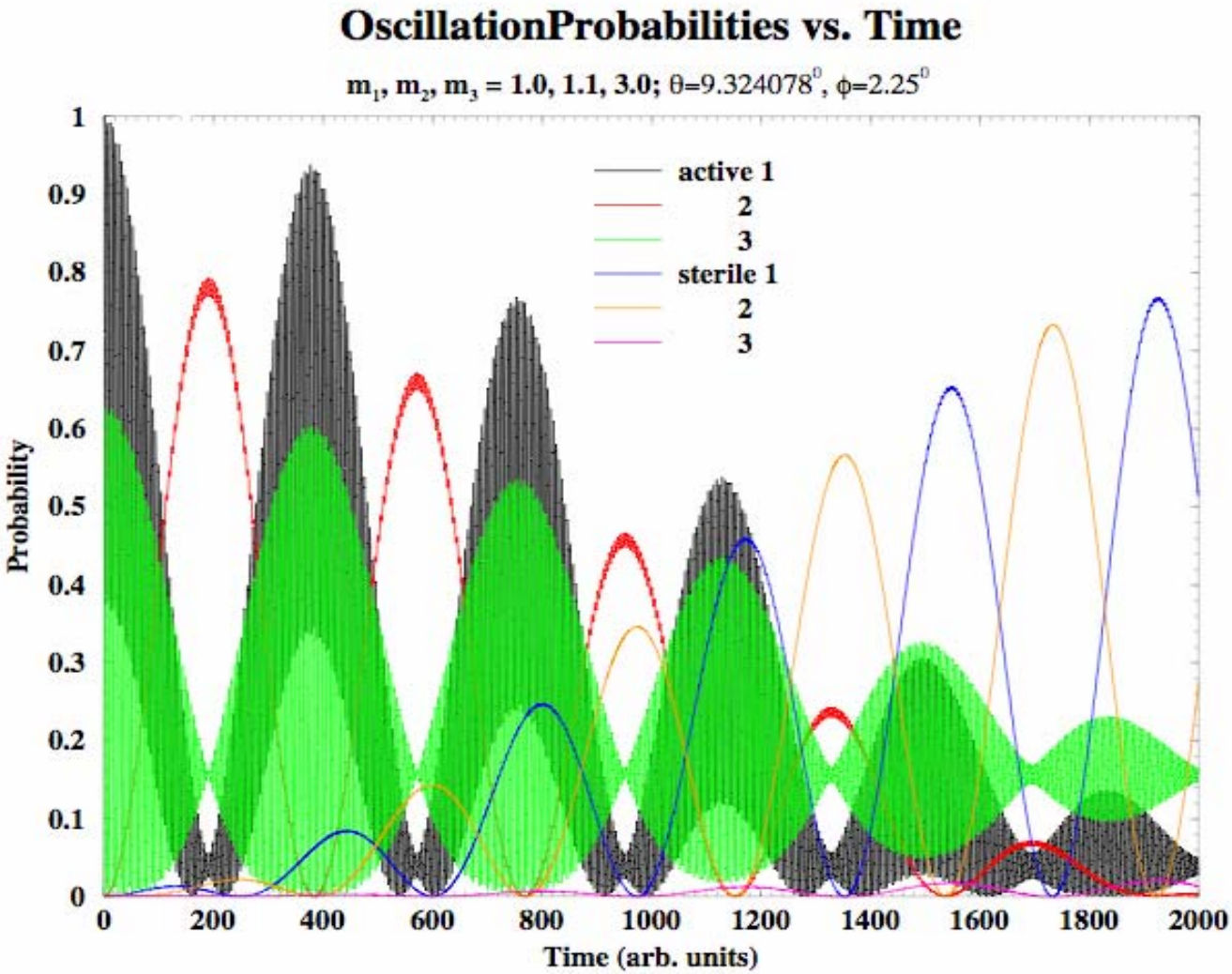


in space defined by
Dirac mass eigenstates

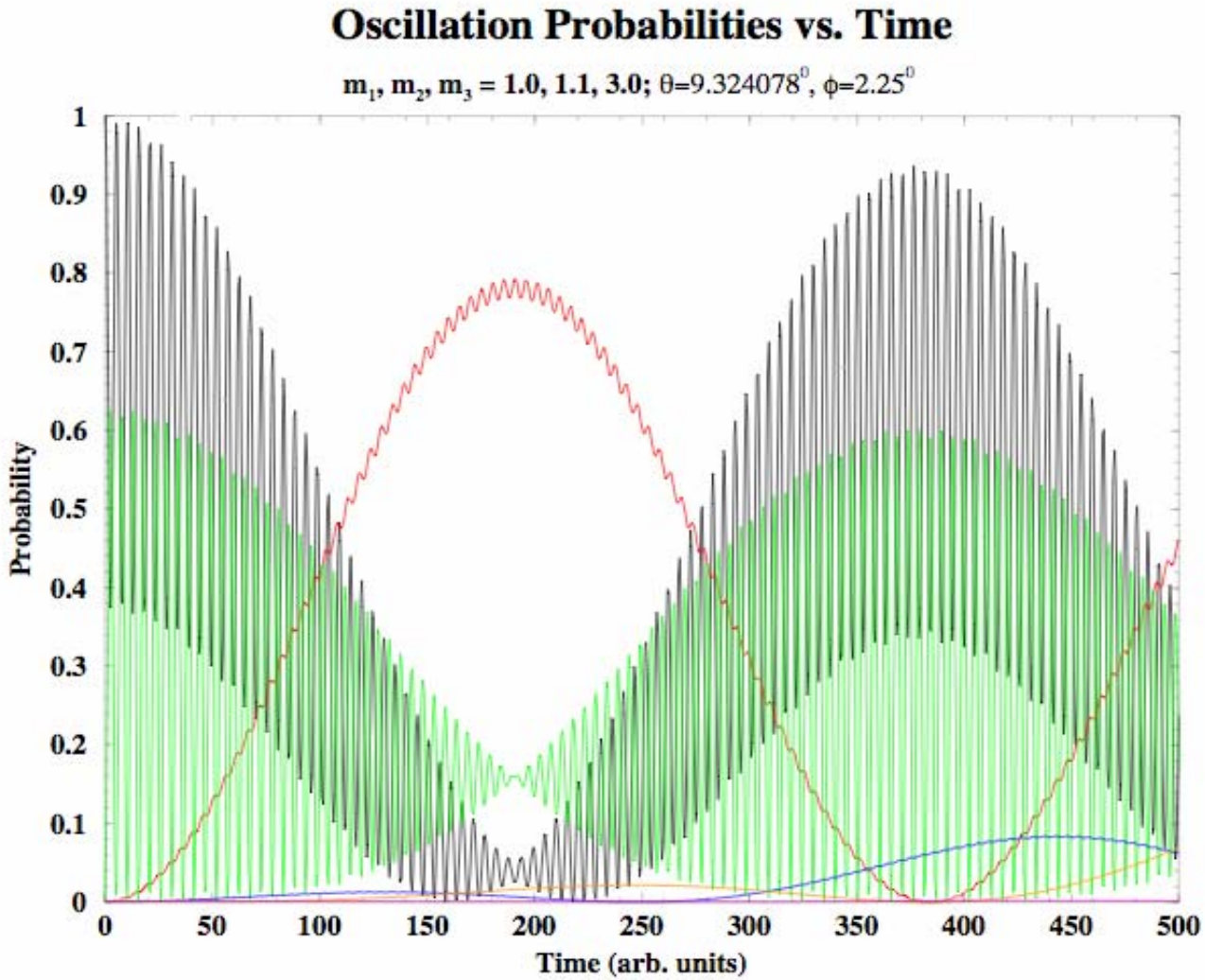
M ⟹ M*

$\cos^2\phi\sin^2\theta$	$\cos\phi\sin\phi\sin^2\theta$	$\cos\phi\sin\theta\cos\theta$
$\cos\phi\sin\phi\sin^2\theta$	$\sin^2\phi\sin^2\theta$	$\sin\phi\sin\theta\cos\theta$
$\cos\phi\sin\theta\cos\theta$	$\sin\phi\sin\theta\cos\theta$	$\cos^2\theta$

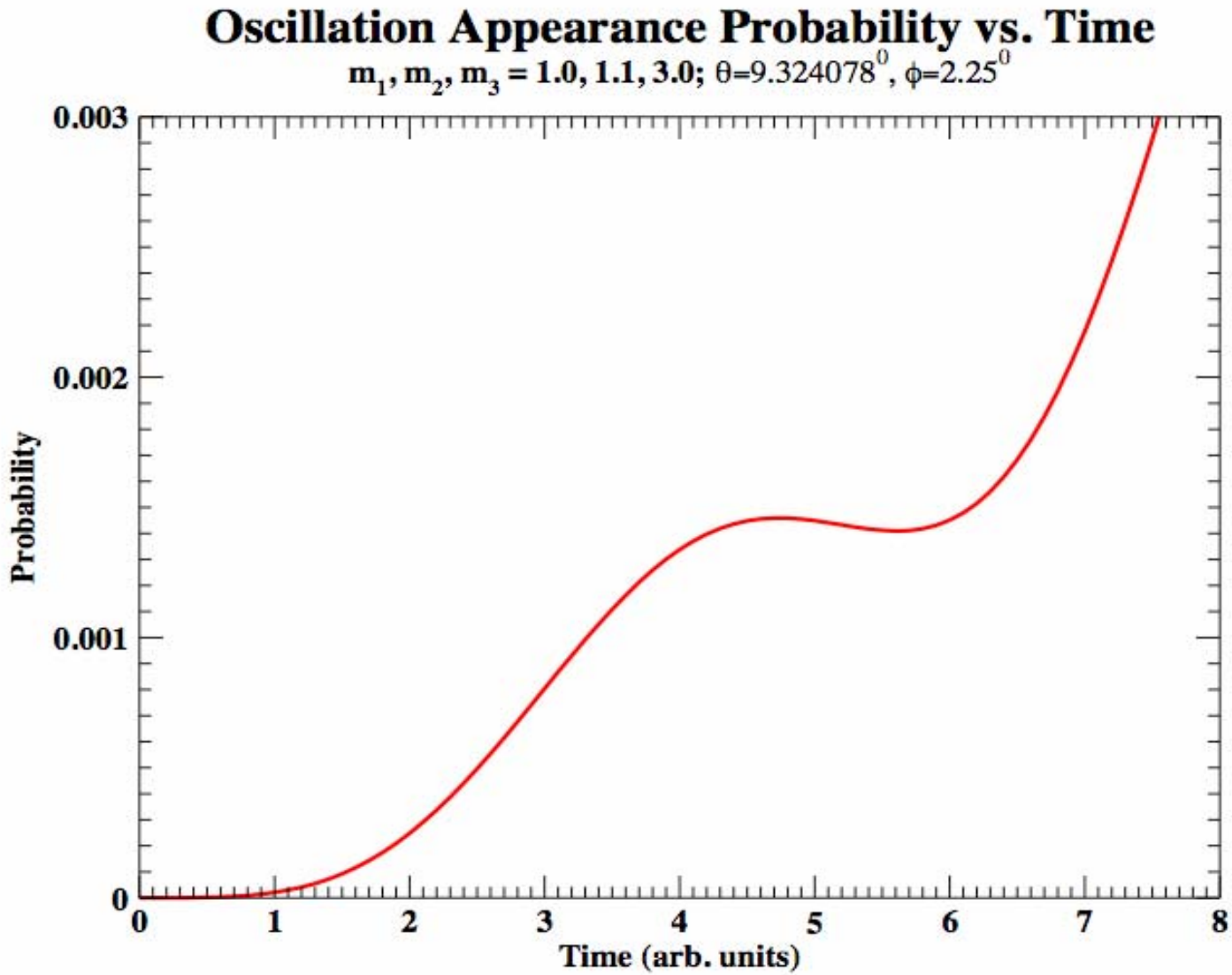
Small angles ϕ, θ for misalignment of sterile and active flavors nonetheless induce large mixing!



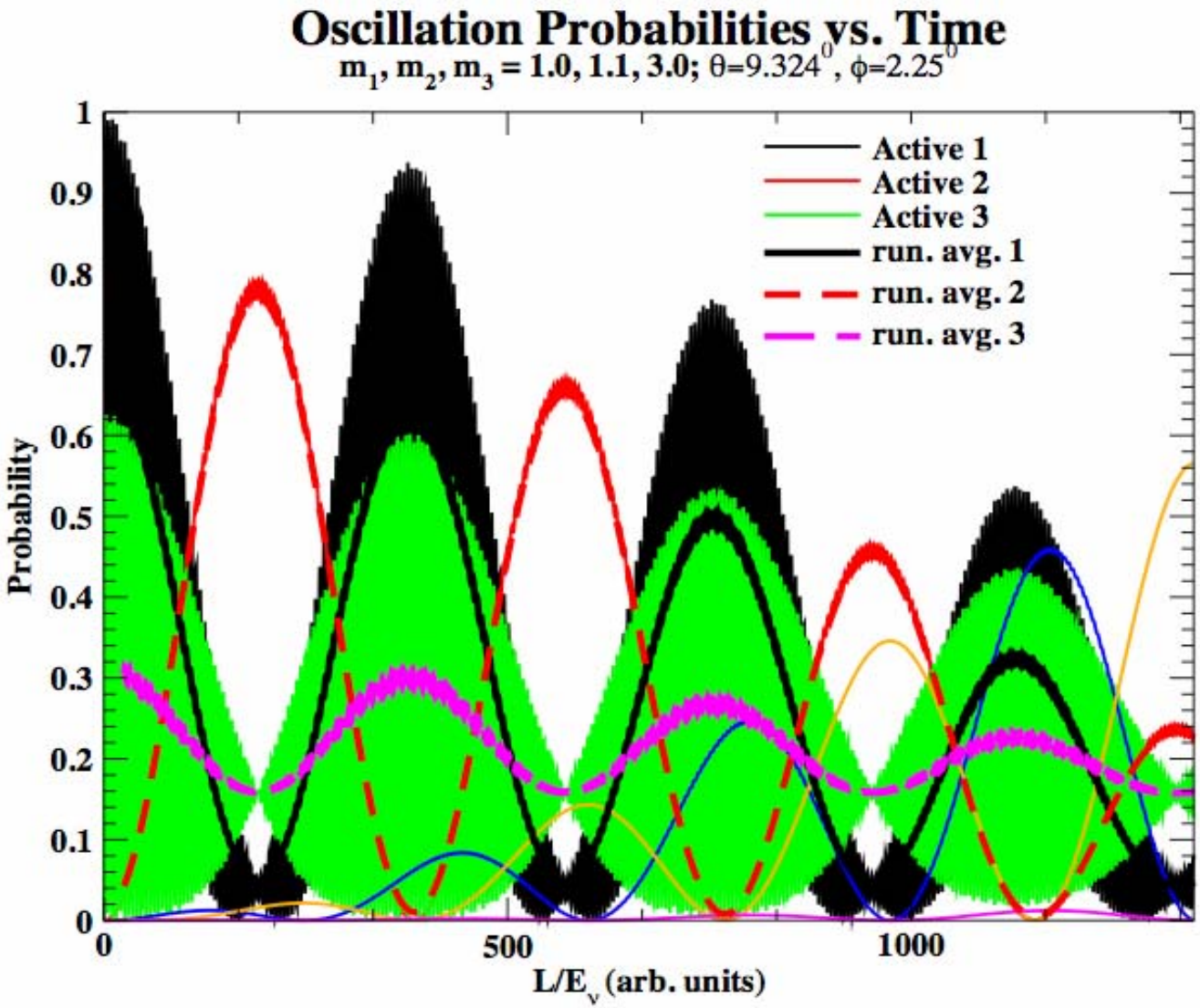
Large mixing amplitudes to all channels on multiple scales



Variation near source



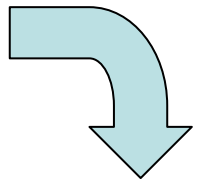
Note probability scale for appearance



Effects of finite resolution

Add CKM (yes, same as quarks) mixing in actives

m_1	0	0
0	m_2	0
0	0	m_3



[Ignoring CPV]

U_{11}	U_{21}	U_{31}
U_{12}	U_{22}	U_{32}
U_{13}	U_{23}	U_{33}

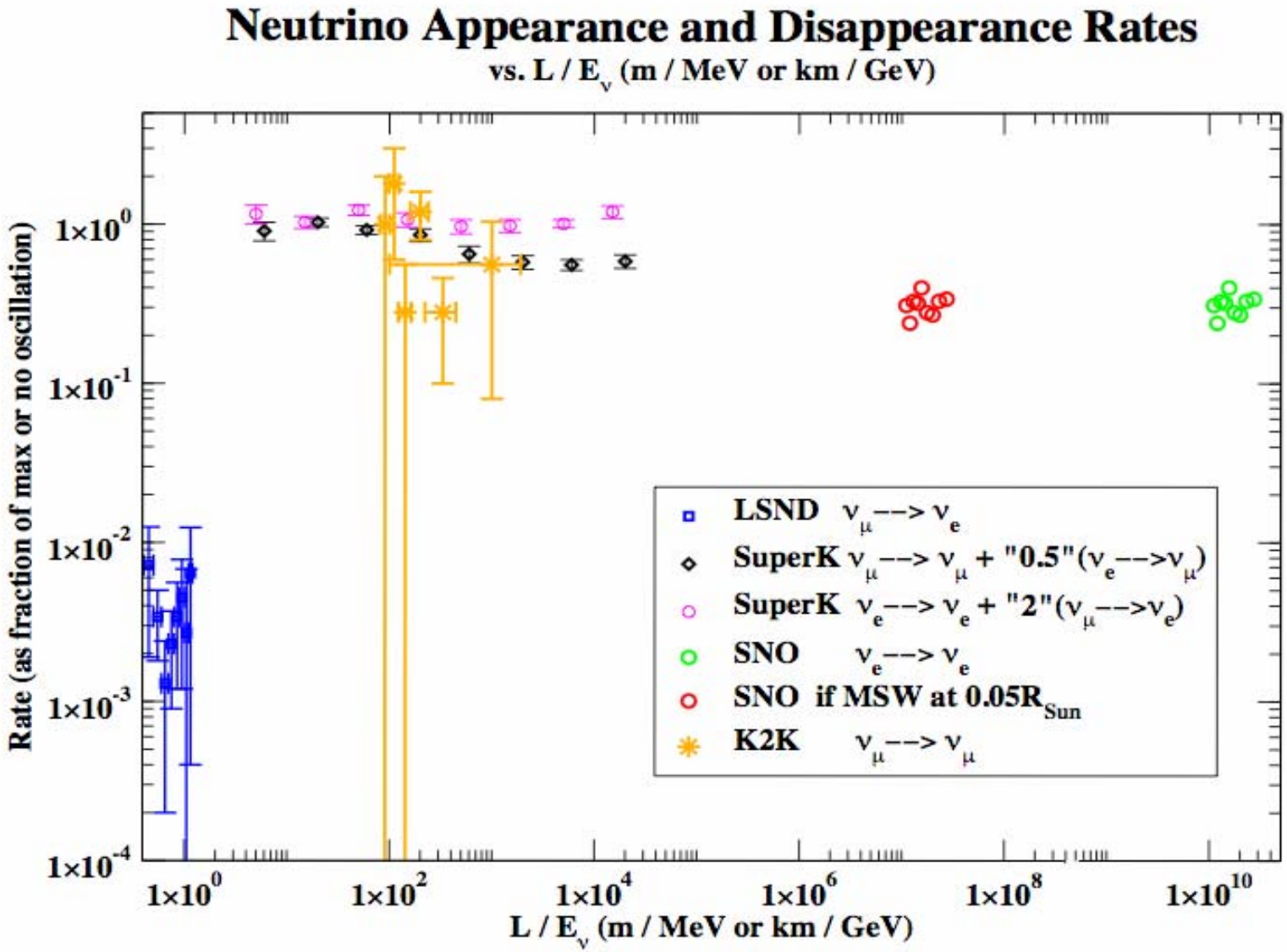
m_1	0	0
0	m_2	0
0	0	m_3

U_{11}	U_{12}	U_{13}
U_{21}	U_{22}	U_{23}
U_{31}	U_{32}	U_{33}

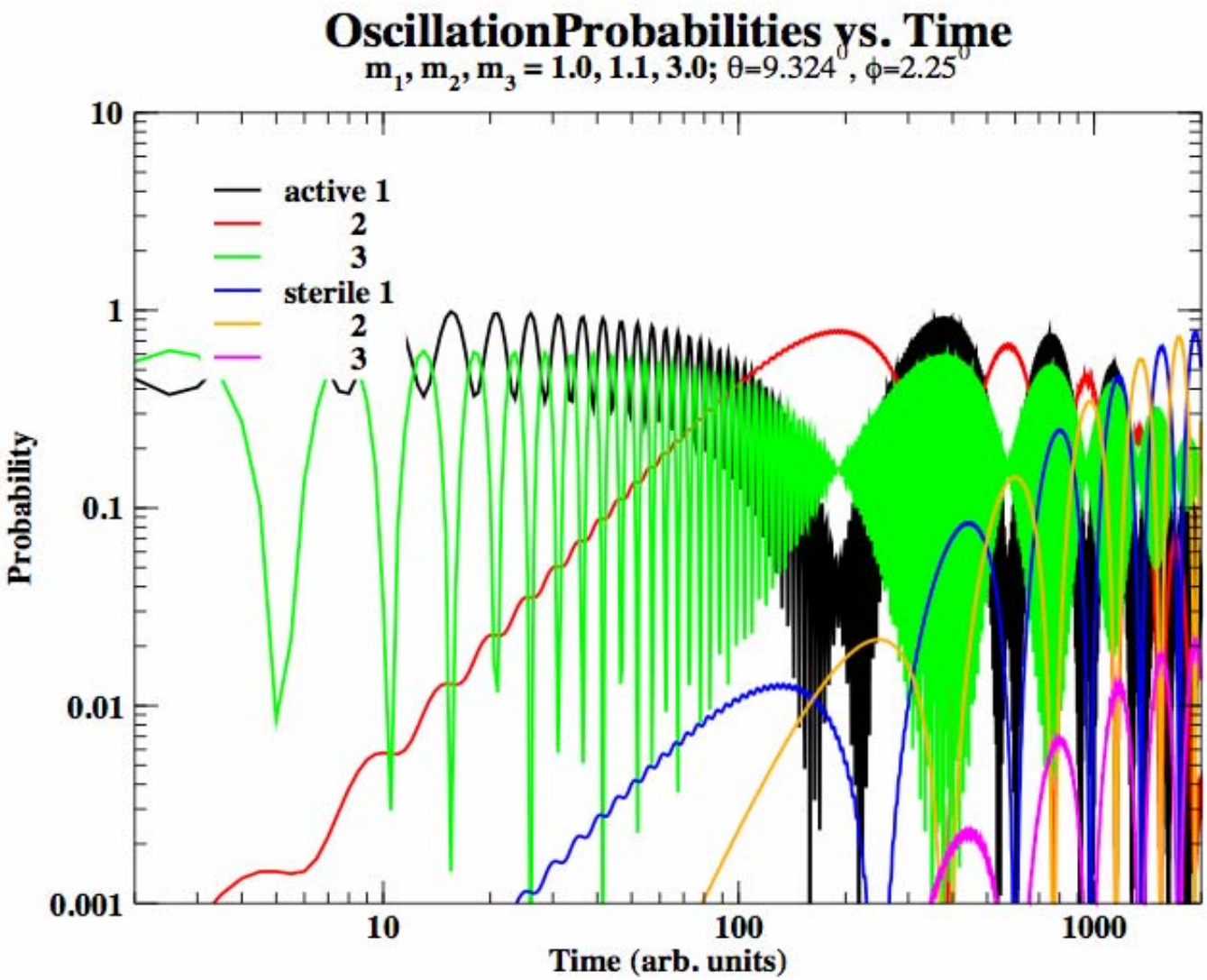
↗Without CKM, L/E scale mismatch for LSND effect

↗Transition probability decreases when L/E scale is adjusted to fit atmospheric

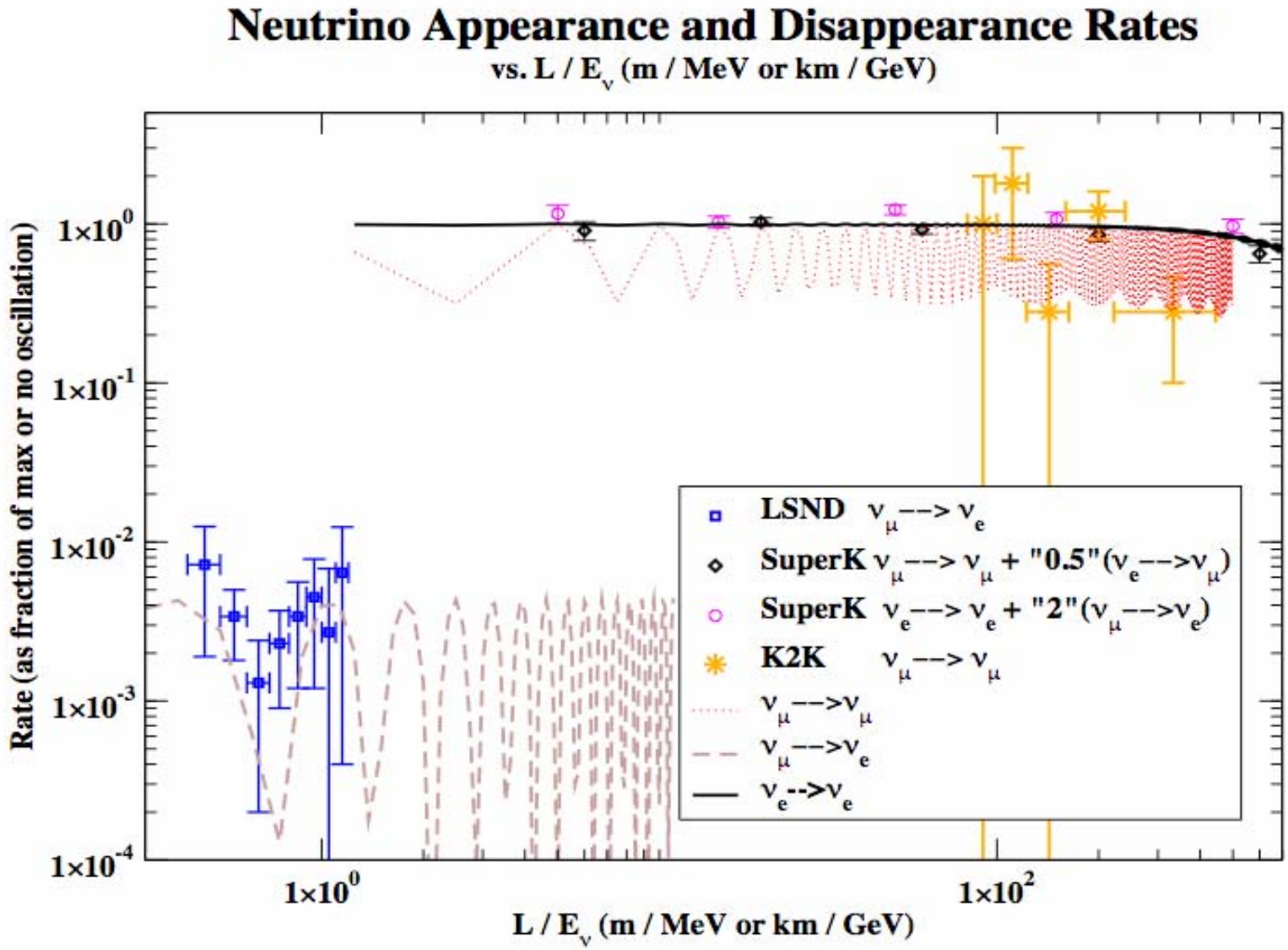
↗Adding CKM restores probability for ν_e appearance without further L/E scale change



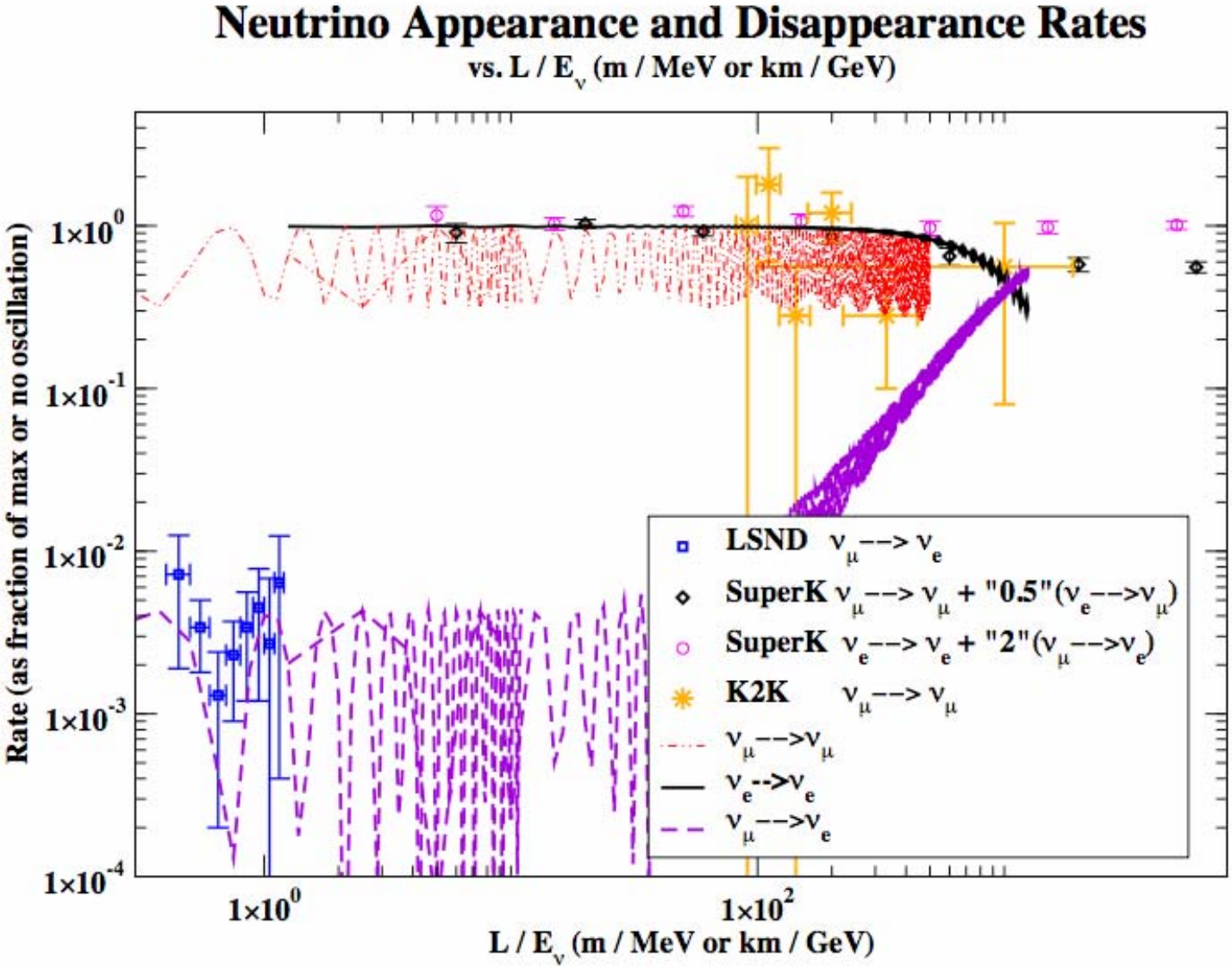
Data in L/E form



Non-CKM results on Log-Log plot as for data



Including CKM revives ν_e appearance rate



Mixing still large -- but too soon?

Remaining questions:

- Wolfenstein effect on ν_e through Earth?
- Further extend scale for ν_μ disappearance?
- Analyze Solar ν's with multichannel MSW

CONCLUSIONS

1. Sterile and Dirac CKM/MNS angles raise questions re conventional analyses limited in channels
2. Reliable data analysis requires having L/E distributions to avoid two-channel biases.